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EXPERIMENTAL STUDY ON AIR COOLING SYSTEM BY USING CONVERGENT NOZZLES

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ABSTRACT

Air conditioners (AC) are costly and most of the Indians use evaporative cooling system i.e Desert cooler for cooling on regular basis. However the use of evaporative cooling system is not favorable in all conditions . Because for comfort we have to consider temperature as well as humidity. The climate of India consists of wide range of weather conditions across a vast geographical scale and varied topography , making generalizations difficult. More over India has a wide range of coastal area. The costal area get hotter in summer and it has humidity too . We can't use evaporative cooling system in these conditions , as it increases humidity which makes the surrounding uncomfortable. Hence, our project aim is to develop an alternative for evaporative cooling and also , to build something which is cost effective and comparatively efficient. In our project rather than using water to reduce temperature which increase humidity, we use nozzles which help in reducing temperature without using water as evaporative cooling system and without using gases as in AC.

Key Word: Alternate to evaporative cooling, Cooling using Nozzle, No increase in Humidity.

I. INTRODUCTION

The climate of India consists of a wide range of weather conditions across a vast geographic scale and varied topography, making generalizations difficult. Climate in South India is generally hotter and more humid than that of North India. South India is more humid due to nearby coasts. So, especially in southern India where coastline has very big impact on climate, there is need of efficient air-cooling system. In India since majority of people are poor or have moderate living standards so it becomes very important that these evaporative cooling systems uses electricity efficiently. India being one such country using desert coolers for cooling on regular basis. But the use of evaporative cooling system is not favourable in every climatic conditions.

So, this project aims to propose the alternative for evaporative cooling. And also, to build something which is cost effective and comparatively efficient.

II. PROBLEM STATEMENT

Evaporative cooling systems are being used widely in India for decades. Evaporative cooling systems are the cheaper and more environmentally friendly alternatives to cooling as it consumes less energy. They work on concept of evaporation of water particles and adding humidity to the environment, resulting into cooling of surrounding air. In evaporative cooling, the fan drafts air from surrounding through the padding system in the cooler. The padding material are wetted using the water provided by using pump. As the hot air passes through the wetted pads the water droplets starts to evaporate and it adds humidity to the passing air. Fan blows the air forward and spreads in surrounding. Because of presence of water molecules in air the temperature of exit stream of air drops and the surrounding atmosphere temperature drops gradually.

However evaporating water system fails to deliver cool air in the monsoon season as humidity level in the atmospheric air is already high and further adding moisture to the room air, increases the level of discomfort. Mainly in the coastal regions of India the humidity is significantly higher which results into hotter climate. In

the monsoon season the humidity increases more and there this conventional method of evaporative cooling has major drawback. As in rainy season there is already so much humidity in air, adding more water to air make cooling ineffective.

Also, some regions of India face the issue of water scarcity. In Rajasthan, there is already the problem of water shortage for daily use also. So, dessert coolers have disadvantage there due to lack of water. Especially in Chennai, people face the problem of water shortage and humid climate both.

So, in above conditions the use of evaporative cooling is not feasible. Therefore, the use of nozzle in air cooling plays important role as an alternative to evaporative cooling systems. By eliminating the conventional padding material and use of water we tried to provide the solution by using convergent nozzles in the cooling systems.

III. WORKING

In this project, we used the concept of velocity changes in the fluid due to convergent nozzle.

A nozzle is a device which increases the velocity of a fluid by decreasing its pressure. In doing so temperature of fluid also decreases. [1,2]

In this cooling system, the modification is done by introducing the convergent nozzle in front side of the cooler box using solid works[3]. Also, the conventional padding materials are replaced with the simple wooden pads on the back and both the sides.

The nozzles are fitted in the wooden board and that board is fixed in front of the fan. In the backside the wooden pads have small holes to draft air with the help of fan.

Fan used in this cooler will be operated at lower speed to eliminated the turbulence and provides gradual flow of air through nozzle.

So, basically fan drafts surrounding air from the back through the holes and throws it forward. Then that air passes through the convergent nozzle through the inlet having larger area. As air passe through the nozzle, due to continuous decrease in the area of nozzle, pressure difference is created.

As the area decrease, initially air goes through compression and then expands, because pressure in nozzle decreases. As a result of expansion, the air temperature decreases.

At the exit, the air is comparatively cool and it spreads into surrounding, providing cooling effect.

In this cooling system we have eliminated the use of water by using nozzles. So effectively it will eliminate the use of pump and reduces cost.

Motor used to rotate the fan is at backside of fan. Armature of motor becomes hot due to continuous use. So, air in this region is relatively hotter and its density will be less. Thus, it will move in vertically up direction. For exhaust of hot air, we have also provided the outlet, exactly upside of the motor.

This nozzle air cooling system does not add extra humidity in the air so it is feasible to used in humid conditions or monsoon season.

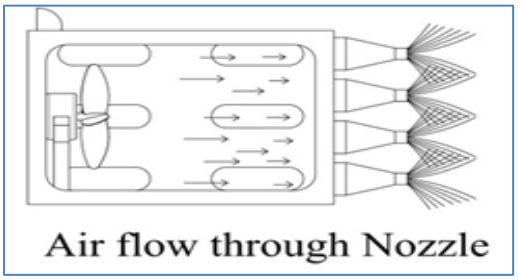

Fig.1. Working Principle

IV. DISCUSSION

Isentropic nozzle flow cooling system will be more Energy efficient as this arrangement of replacing cooling pads of evaporative cooling system with small nozzles built in the pads will result in more energy efficient cooling system[4]. Since nozzle arrangement will not require cooling fluid for cooling so the energy required by pump to throw the cooling fluid towards the pads will be reduced as there will be no requirement of the pump. This will also remove the requirement to fill the cooling system with cooling fluid. This will also help in preventing humidity from increasing in monsoon season as no water is added here. Another advantage of nozzle build pad is that the size of cooling system will be hugely reduced and the cooling system will become compact as it does not require water spraying unit as well as water storage unit. Another support of using such type of cooling pad is that it could be used both ways that in front of fan or at back of fan to give cool air. Also in summer this cooling unit will give cool air but if we use the cooling pad backward that is exit point of nozzle where temperature is T2 is placed outside to open and entry point of nozzle where temperature is T1 is kept towards fan. Than from formulae we know T1 is higher than T2 therefore the temperature of air from fan will be higher so the cooling unit could be used as blower in winter.

Suppose,

area at Entry of nozzle is A1, Velocity is C1, Temperature is T1, Pressure is P1, Specific enthalpy is h1

Exit of nozzle be A2, Velocity is C2, Temperature is T2, Pressure is P2, Specific enthalpy is h2.

Steady State Equation :-

$h1 + C1^2/2 + gZ\ 1 + Q = h2 + C2^2/2 + gZ\ 2 + W$

Since no work is done in nozzle, heat exchange is also very little comparable to 0,

$C1^2/2 - C2^2/2 = h1-h2$

If velocity at entry is very small C1=0 For the case of air: h1-h2= Cp (T1-T2)

In Subsonic Flow Mach number is Ma < 1

In Sonic Flow Mach number is Ma = 1

In Super Sonic flow Mach number is Ma > 1

Any quantity with a zero subscript refers to a stagnation point where the velocity is zero, Let the pressure and temperature at throat be Pt and Tt.

So, $Pt/P1 = (2/\gamma + 1)^{\gamma/\gamma-1}$ and $Tt/T1 = 2/\gamma + 1$ Where, γ is heat capacity ratio which for air is 1.4.

Hence temperature at throat = 0.83 times temperature at entry. In summer the temperature of air is suppose 35^0 Celsius. So, after passing through nozzle the temperature of air will be reduced to 29^0 Celsius according to theory. Hence, theoretically the use of nozzle for cooling could work very well. So, we can say that nozzles can reduce the temperature of air by some degrees.

V.CONCLUSION

In this project we have tried to replace the conventional cooling pads with using nozzle pads at front. We also eliminated the use of water in the cooler. As a result of which, this nozzle air cooling system is beneficial in the humid hot coastal region and monsoon season. Also, it is beneficial in regions having water scarcity, as there is no need of water.

In this project, we used natural product like wood or bamboo and waste material like plastic bottles. So, it will be lot cheaper than conventional dessert cooler and affordable for the poor.

Nozzle flow coolers can therefore be used to improve the human thermal comfort in residences, schools, commercial centres, hospitals, and industries provided the main parameters for cooling fall within the recommended range.

Hence, we conclude that cooling systems with nozzle built in pads could be a great alternate to cooling air by evaporative cooling and it has many advantages over evaporative cooling systems. We can conclude that this project is efficient and cost effective.

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